Mars Exploration Program Analysis Group (MEPAG)

chartered by NASA HQ to assist in planning the scientific exploration of Mars

Report to PSS

Lisa Pratt, *MEPAG Chair*

March 31, 2015

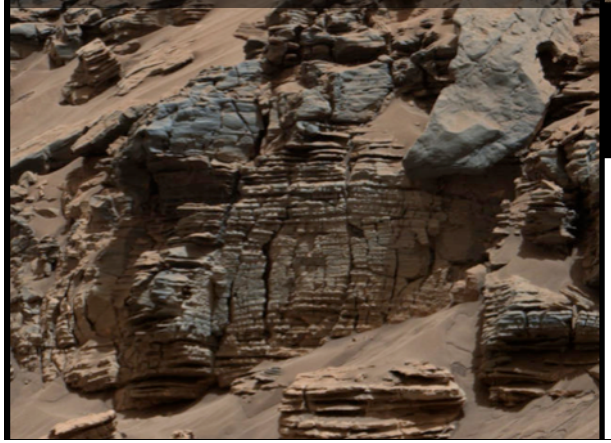
NASA/JPL-Caltech/MSSS

← Mount Sharp

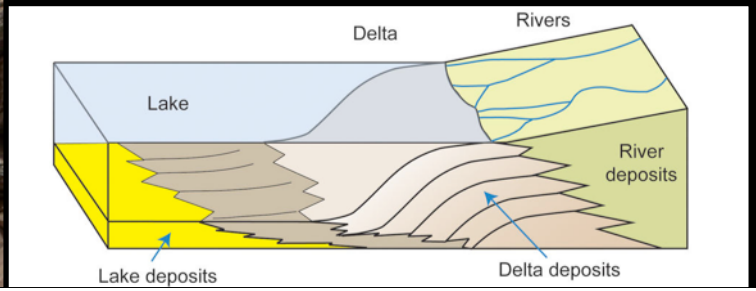
meters 0 2 4 6 8 10

centimeters 0 20 40 60 80 100

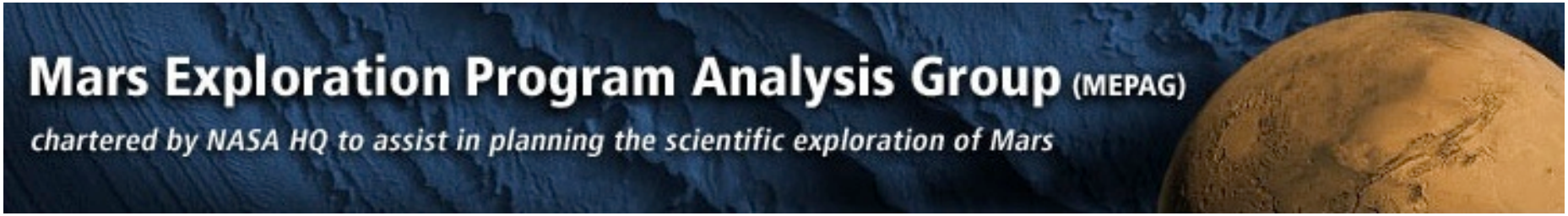
Possible Lake Deposits?



Curiosity Explores Pahrump Hills site



Hypothesis: Do southward-tilted sandstone beds on Gale Crater's plains indicate fluvial transport of sediment toward Mount Sharp, building up lake deposits there?



MEPAG Face-to-Face Meeting

Tuesday, February 24, 2015

08:15 AM	Welcome, *L. Pratt*
	New Leadership
08:35 AM	NASA: MEP Status/Mars Future plans, *J. Watzin*
09:30 AM	HEOMD plans, interactions, *B. Bussey/R. Davis*
10:00 AM	MEPAG response to NASA presentations, *L. Pratt*
10:20 AM	*Break*
	Flight Program Status
10:40 AM	Mars Science, *M. Meyer* (call-in)
11:00 AM	NASA MEP Mission Status, *F. Li*
11:25 AM	Update from 2020 Rover project, *K. Farley*
12:00 PM	*Lunch*
01:30 PM	European Perspective/ExoMars planning, *R. de Groot*
02:00 PM	Japanese Mars Planning, *H. Miyamoto*
02:15 PM	Emerging Technologies/Mission Capabilities, *C. Whetsel/R. Lock*
02:45 PM	*Break*
	MEPAG Goals Document
03:15 PM	MEPAG Goals Revision , *V. Hamilton & Goals Committee Members*
05:45 PM	Day 1 discussion and wrap-up, *L. Pratt*
06:00 PM	*Adjourn*

Wednesday, February 25, 2015

08:00 AM	Agenda and actions for today; follow-up on Goals presentation; future activities, *L. Pratt*
	New Mission Results!
09:00 AM	MAVEN Early Results & Prospects, *D. Brain*
09:40 AM	MOM Early Progress, *R. Zurek*
10:00 AM	*Break*
	Landing Site Activity
10:20 AM	The 2016 InSight Mission & L/S Process, *B. Banerdt/M. Golombek*
10:50 AM	Future Landing Site Observing, *J. Grant/ M. Golombek*
11:15 AM	ExoMars landing site process, *J. Vago*
11:35 AM	Discussion: Landing Sites for Human Missions, *R. Davis*
11:55 AM	MEPAG action Items; Wrap-up, *L. Pratt*
12:15 PM	*Adjourn*

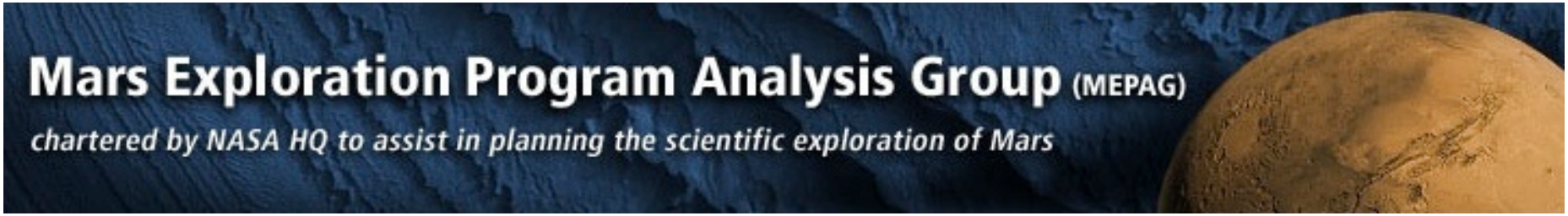
New Leadership for Mars Activities

First opportunity for MEPAG community to meet new leadership

- *Mars Exploration Program Director*: James Watzin
- *HEOMD Chief Exploration Scientist*: Ben Bussey
- New in PSD—*Assistant Director for Science and Exploration*: Richard Davis

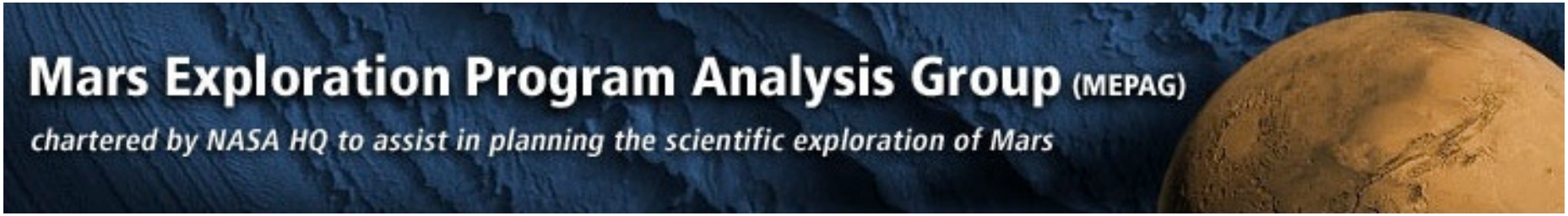
Focus: Activities in the 2020's and beyond

- 2020 Mars rover begins this era of future robotic and human exploration
  - Payload includes science instruments, in situ resource utilization demonstrator, sampling equipment
  - What next?
- Studies are being initiated to follow up on near-term needs after 2020:
  - Replenish relay/reconnaissance infrastructure
  - Make scientific and technical progress on Decadal Survey priorities (e.g., sample return) and to follow up new discoveries (e.g., Recurring Slope Lineae)
  - Locate *in situ* resources for future robotic and human exploration
  - *Foster closer coordination and exploit synergies between scientific and resource measurement capabilities*



Roles for MEPAG

- **NASA HQ has requested two analyses by MEPAG:**
  - Analyze potential science and resource objectives for a possible new orbiter to be launched in 2022/2024
  - Analyze potential science objectives for a landed human mission on Mars in the 2030's
- **MEPAG has tentatively agreed, pending receipt of the study charters.**
  - These analyses are to be co-chartered by HEOMD Exploration and SMD PSD/MEP
  - The charters are currently in work and the SAGs expected to start work in April
- **MEPAG will conduct this work via 2 Science Analysis Groups (SAGs)**
  - *Next Orbiter SAG (NEX-SAG) to analyze:*
    - Relevant scientific objectives derived from the revised MEPAG goals document
    - Needed measurement capabilities to locate *in situ* resources needed by future human missions
    - Synergies between the two sets of measurements
  - *Human Science Objectives SAG (HSO-SAG) to analyze:*
    - Our anticipated level of scientific knowledge at time of landing humans on Mars
    - What science should be advanced by humans based on the Mars surface?
      - Includes providing information about where the base(s) for humans should be.
    - This is part of a larger joint HEOMD/SMD study looking at exploration locations on Mars.



MEPAG Goals Document Revision

Purpose of the Goals Document

The MEPAG Goals Document aims to provide sufficient information to:

- Reflect the scientific priorities of the MEPAG community with respect to investigations for future flight missions,
- Guide NASA's Mars Exploration Program (MEP) in its advance planning of Mars flight missions,
- Help NASA develop Announcements of Opportunity and Proposal Information Packages for missions with science objectives, and
- Support the mission and instrument selection process by helping NASA distinguish those science investigations likely to make substantial (vs. incremental) advances.

This document does NOT specify implementation or imply a timeline for conducting the investigations.

Provides for direct input from the science community as to what should be the scientific core of future Mars Exploration.

Purpose of this Revision

- **Bring the document up to date with respect to science advancements in all Goal areas**
  - E.g., science results presented at 8th Mars Conference (2014)
  - E.g., aims of the HEOMD Evolvable Mars Campaign
- **Increase cohesion and usability of the document, reflecting connections in current research**
  - Clarify language and intent
  - Many changes involve reorganization and amplification of previous content
- **Prepare for upcoming activities (e.g., SAGs)**

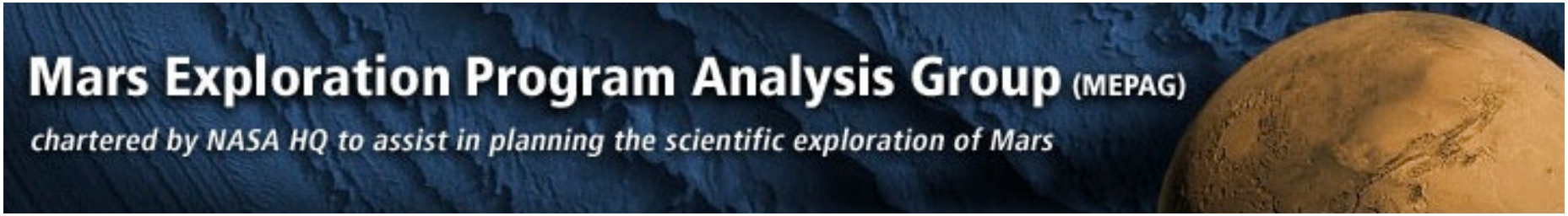
MEPAG Goals *Committee* ***Vicky Hamilton, Chair***
Goal I, Life ***Jen Eigenbrode*** ***Tori Hoehler***
Goal II, Climate **Scot Rafkin** **Paul Withers**
Goal III, Geology ***Steve Ruff*** ***Aileen Yingst***
Goal IV, Preparations for Human Exploration ***Darlene Lim*** ***Ryan Whitley***

Changes to Goals Document

- **Added new level in hierarchy: Sub-Objectives**
  - Reflects detailed questions arising for a complex planet and provides a better way to distinguish priority within an Objective.
- **Extent of Changes:**
  - **Goal I, Life**: Relatively *minor*, transitioning from habitability to seeking biosignatures
  - **Goal II, Climate**: *Significant* augmentation
  - **Goal III, Geology**: *Extensive* revision and re-organization
  - **Goal IV**, Preparation for Human Exploration: *Significant* reorganization and re-prioritization

MEPAG Meeting Draft of Revised Goals Document available on http://mepag.jpl.nasa.gov/

- **Status**:
  - Presented and discussed at MEPAG face-to-face meeting Feb. 24-25, 2015
  - Poster presented at LPSC and final comments were due March 20
  - Comments now being addressed => ***final release ~ 1 May***

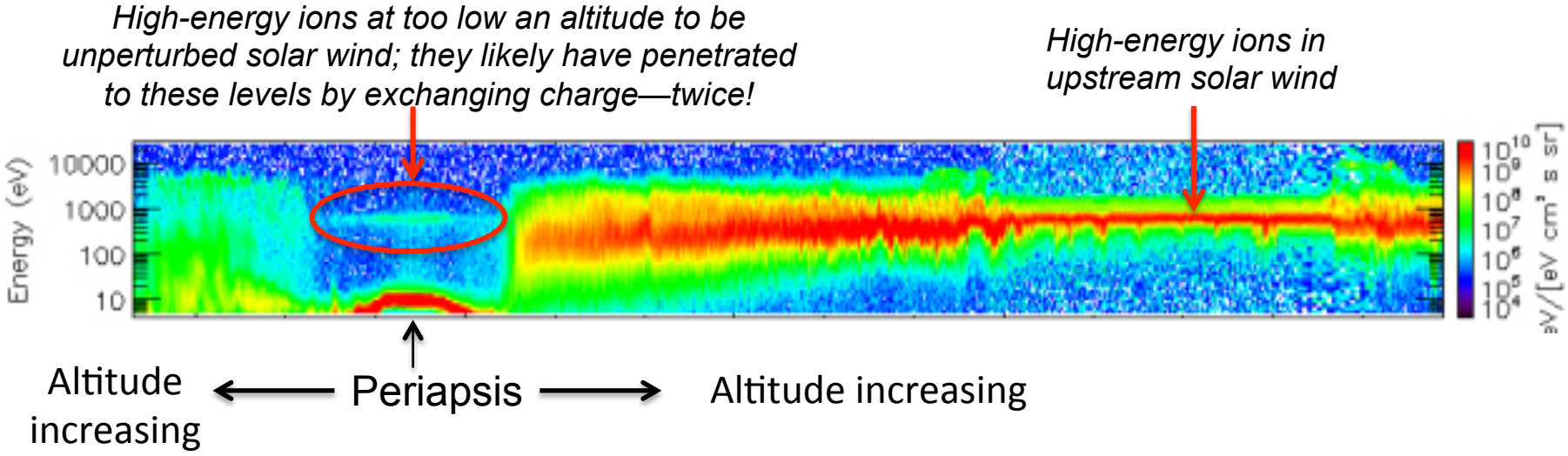


Mars Science Highlights

Some recently published, others reported at
MEPAG meeting and LPSC

MAVEN: New Solar-Wind Penetration Process

• **MAVEN/SWIA** • **Finding:** High-energy Solar Wind ions were detected low in the atmosphere (near MAVEN periapsis)—how did they get there?	• **Importance:** MAVEN has discovered a new phenomena likely involving energy exchange in which high-energy solar wind ions are neutralized and able to penetrate the bow shock, only to be re-ionized lower in the atmosphere, providing an unexpected lower altitude ion source.



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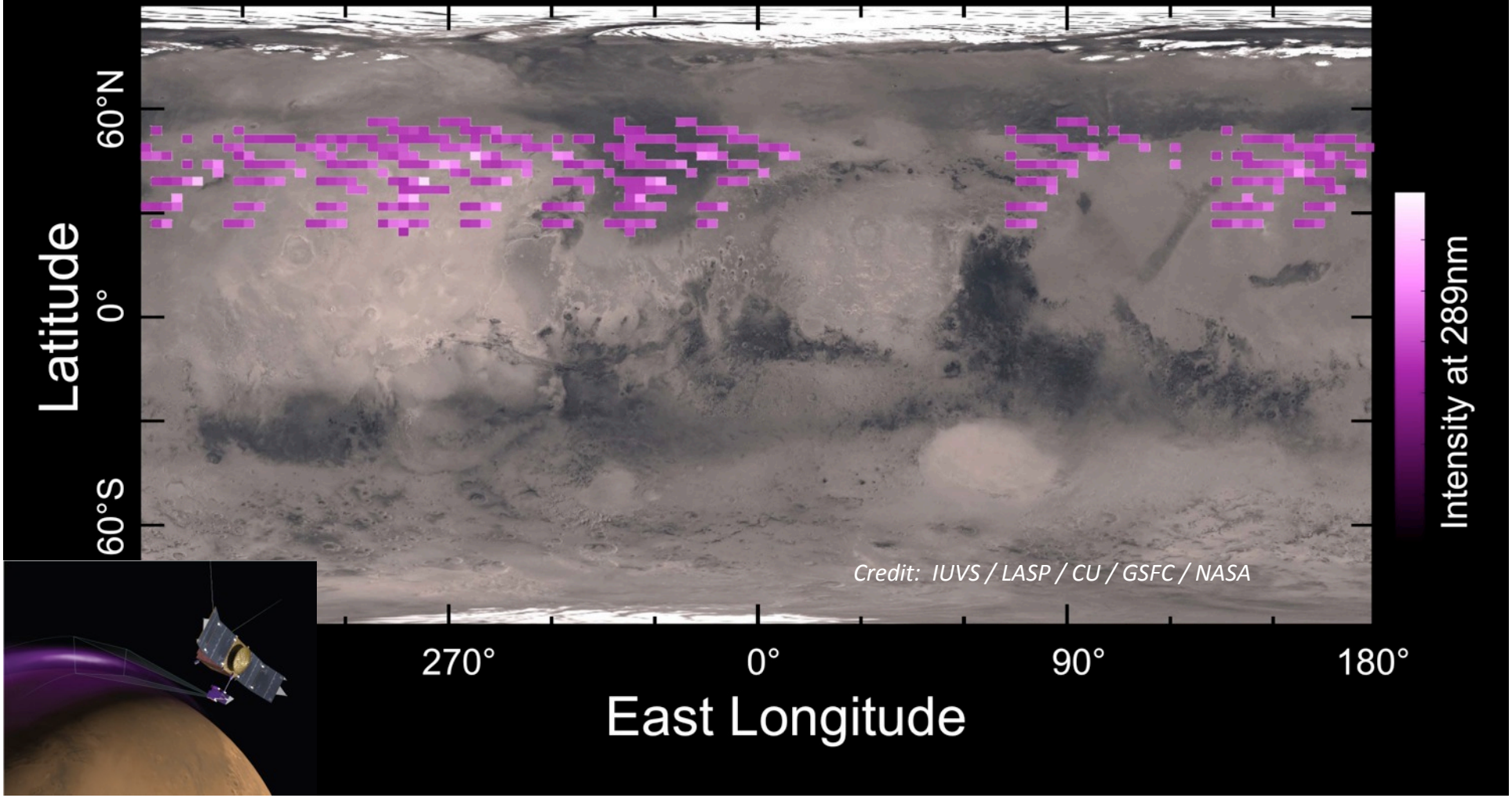
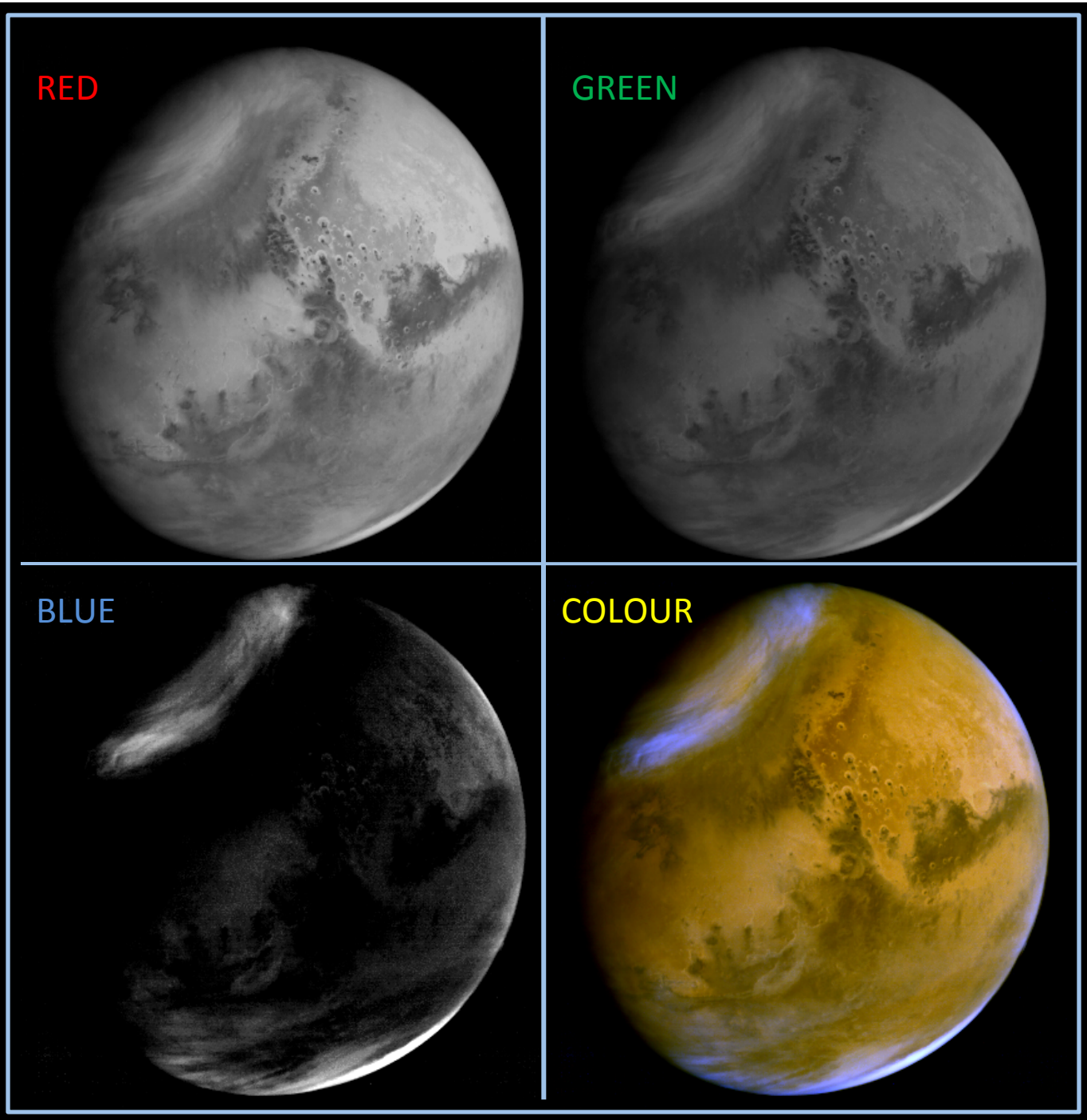
MAVEN: New Results

Ultraviolet Aurora on Mars





Mars as seen in three Colors by (MOM) Mars Orbiter Mission Mars Color Imager

October 1, 2014

- The red wavelength shows the best surface details.
- As the Mars atmosphere scatter blue (like Earth) Martian surface details are obscured in blue wavelength.
- Blue wavelength band shows scattering by dust and clouds , mainly atmospheric phenomenon

Credit: India Space Research Organization

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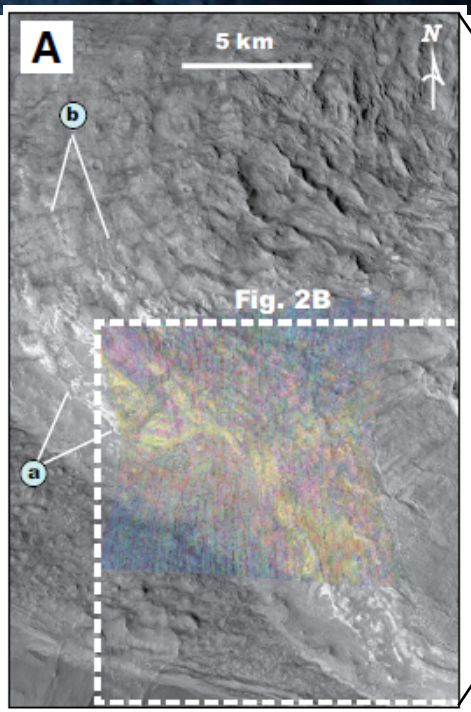
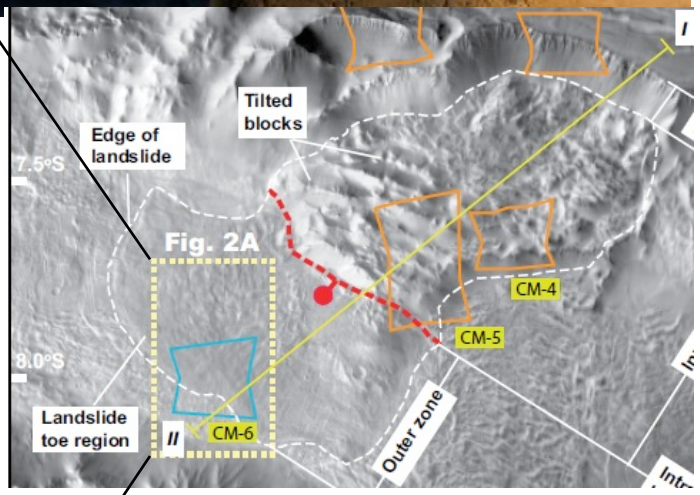
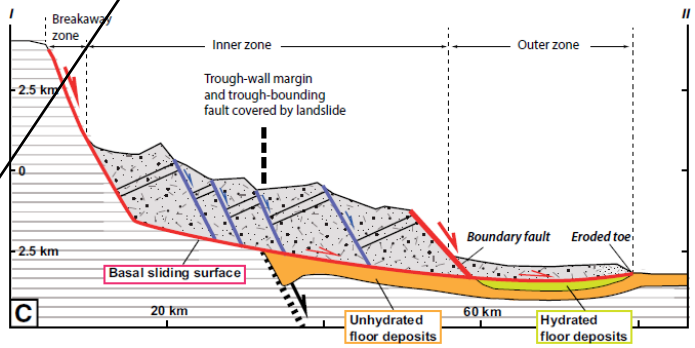
Mystery Explained?

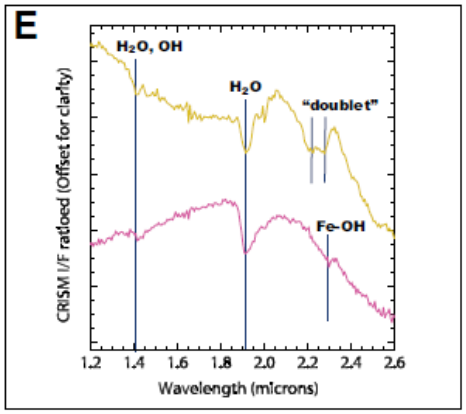
Valles Marineris Landslides Shaped by Hydrated Silicates

- ***MRO/CRISM+HiRISE***
- **Finding:** Clay minerals likely lubricated landslides from the walls so that they extend for unusually long distances.
- **Importance:** Aqueous alteration early in Mars' history has had long lasting effects, manifested by the interaction of clay minerals with large-scale surface processes even in present times.



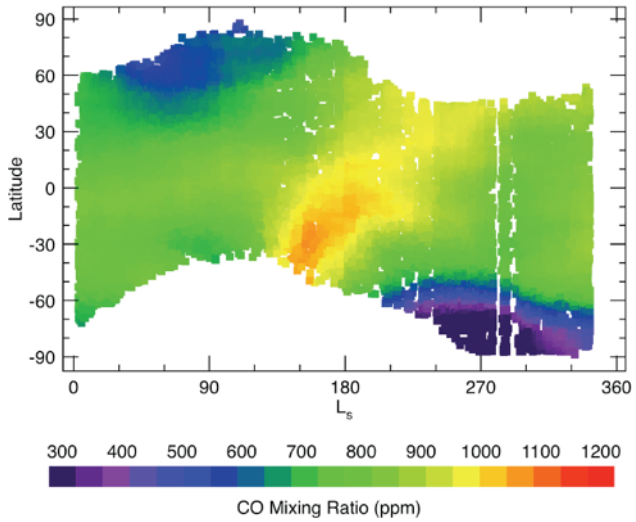






Reference: *Watkins, J. A., Ehlmann, B. L., and Yin, A. (2015) Long-runout landslides and the long-lasting effects of early water activity on Mars, Geology, doi: 1130/G36215.1*

- ***MRO/CRISM***
- **Finding:** The winter hemispheres have CO-enrichment in topographically low areas
- **Importance:** CO traces the circulation of CO_2-depeleted air from which the seasonal cap condensed. The cold residual gas collects in topographic lows.
- ***Reference:*** *Smith, M.D. (2014) Seasonal and spatial distribution of carbon monoxide on Mars as observed by CRISM, Fall 2014 AGU, abstract P51B-3914*

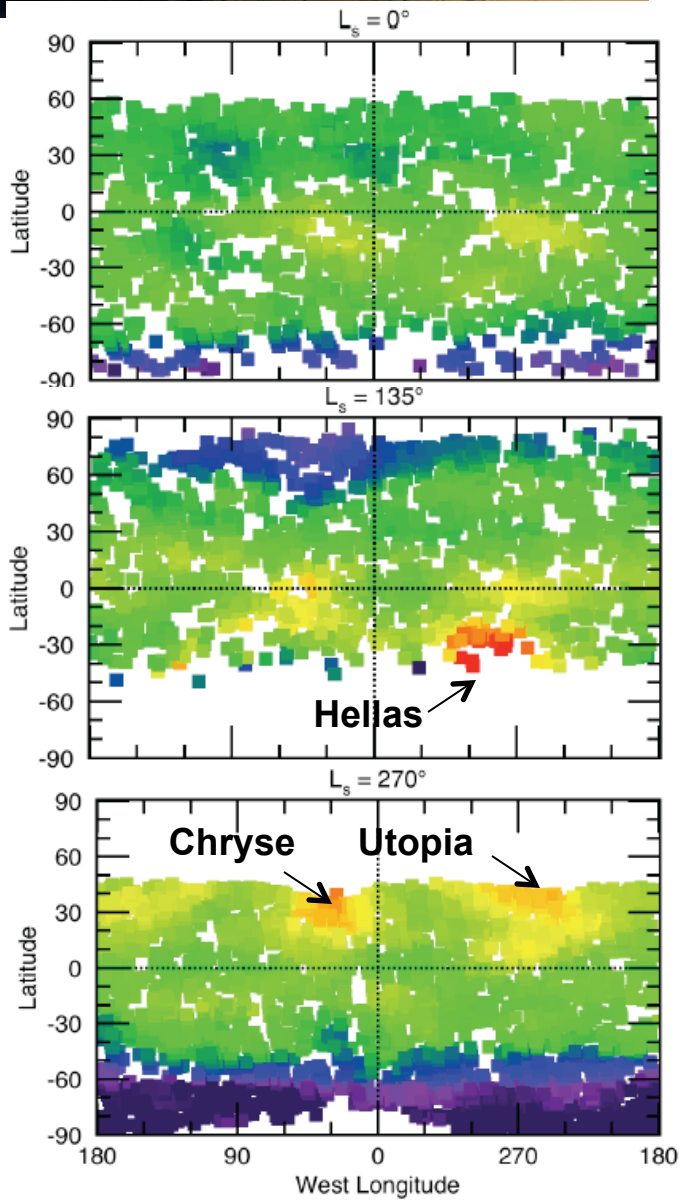


Zonally averaged CO mixing ratio vs. L_s hides geographic variations

Equinox – spatially uniform composition

S. winter – CO enrichment in S. hemisphere low area

N. winter – CO enrichment in N. hemisphere low areas



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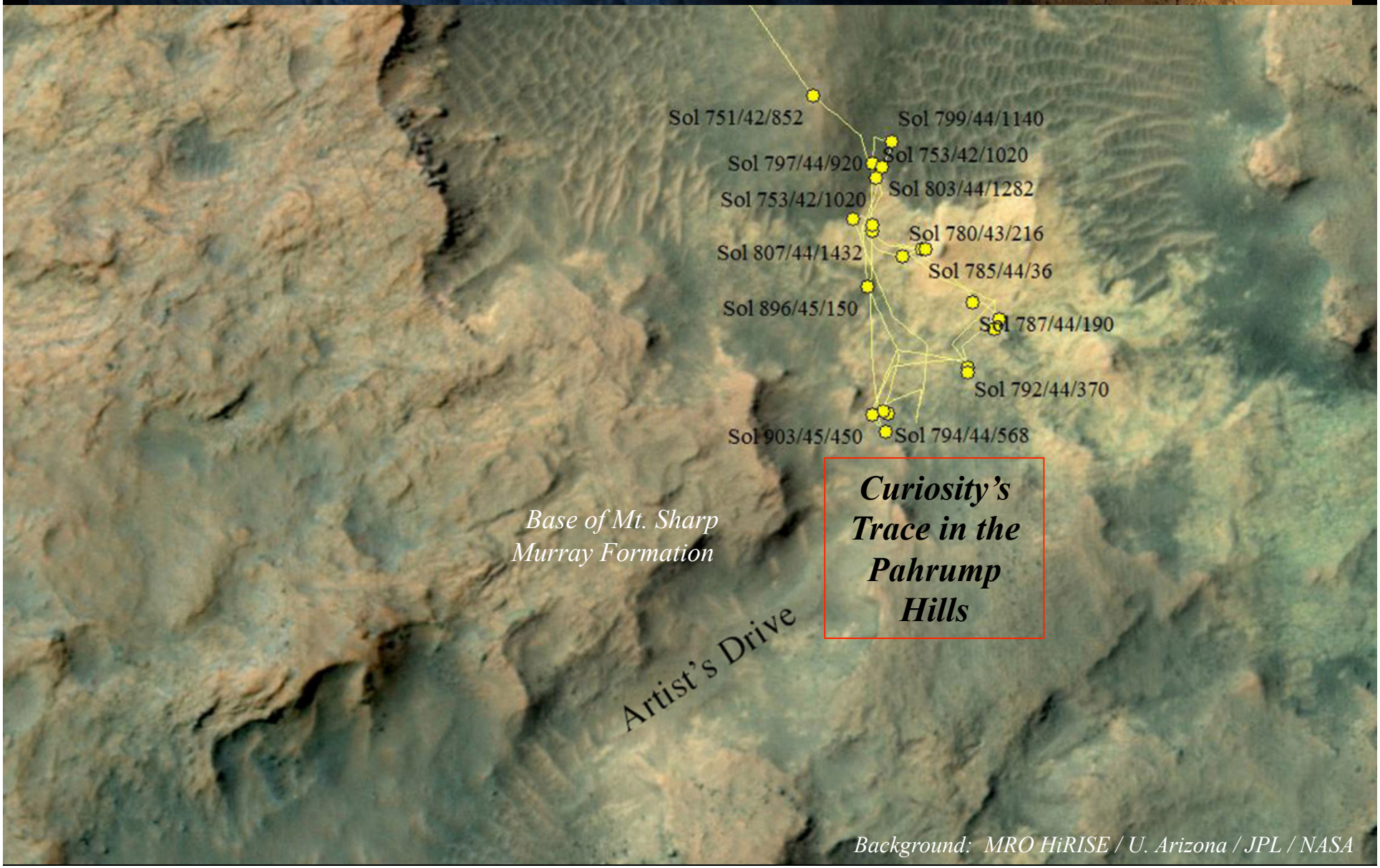
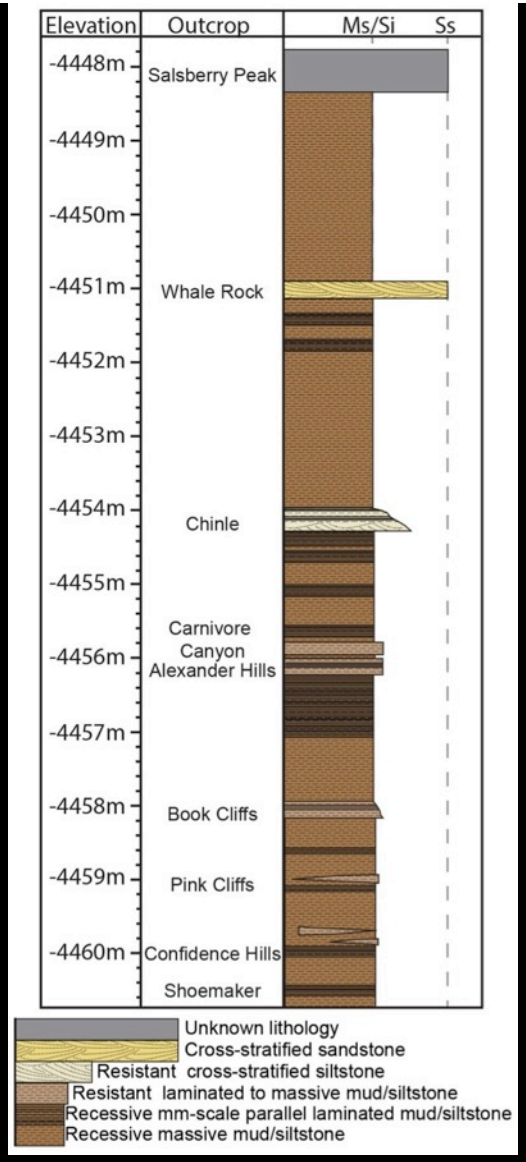
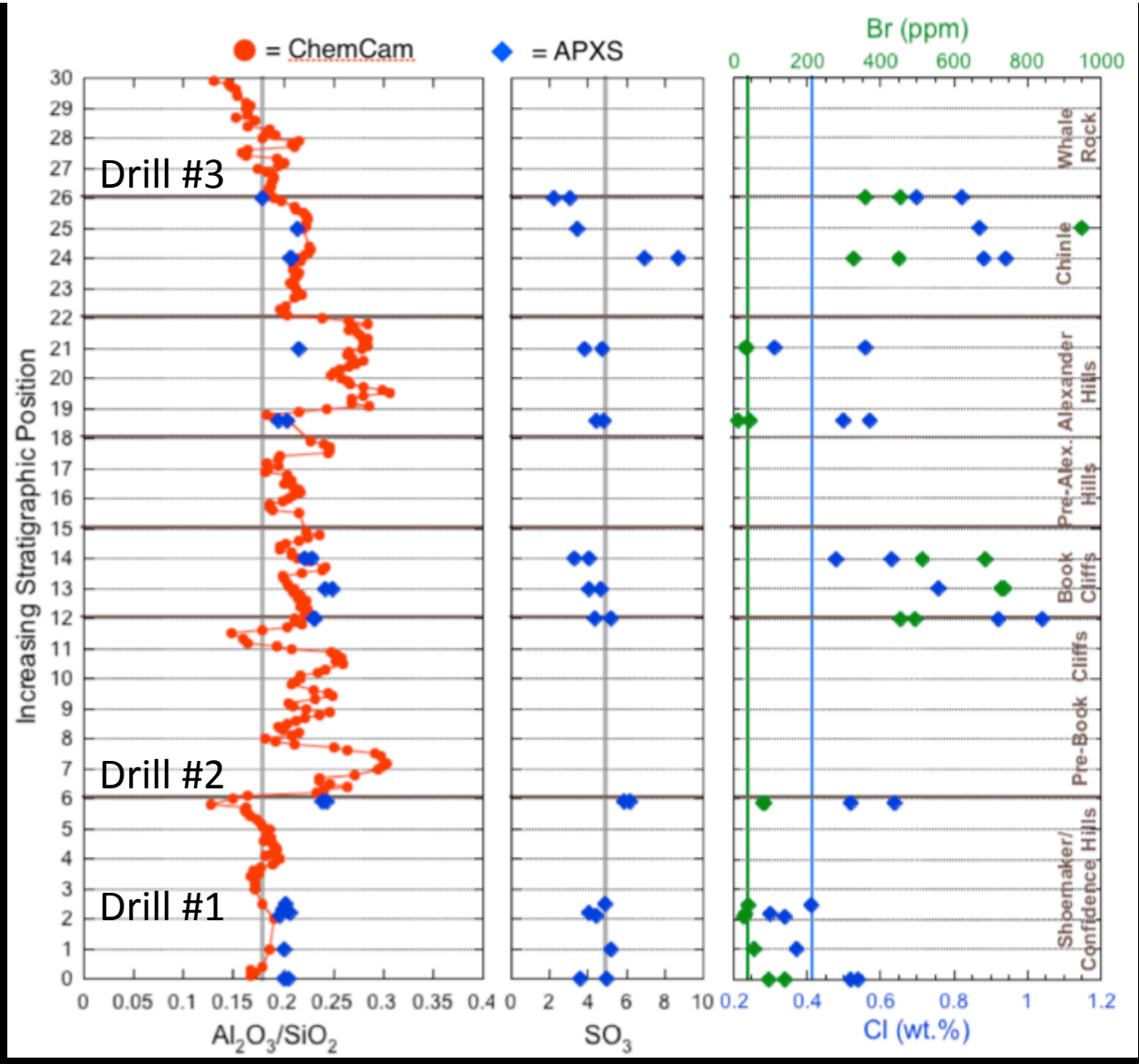




Stack et al. (LPSC 2015)



Milliken et al. (LPSC 2015)

At Pahrump Hills a first pass through the 10-m section surveyed morphology and chemistry. A second pass through the section built a large data set of physical and chemical stratigraphy (above). A third pass has provided XRD & GCMS analyses at three drill sites.

A Sample of Recent Highlights

- **Curiosity (prime & extended mission):**
  - Measured an unexpected, short-term enhancement of methane.
  - Stratigraphic observations suggest the sediments in Mt. Sharp and in the surrounding plains were emplaced by a series of streams and lakes.
  - Found chlorobenzene, a simple organic chemical, in its analysis of mudstone from Yellowknife Bay. (Took many lab runs on Mars & Earth to confirm.)
  - *Tentative* discovery of long-chain (~10) carbon molecules in same Yellowknife mudstone.
- **MRO (extended mission):**
  - Found larger volume of *buried* CO_2 ice than previously surveyed, enough to double the present atmospheric mass if released.
  - South polar *surface* CO_2 ice cover results from a complex balance between the expanding pits (the "swiss cheese" terrain) and new deposition of CO_2 snow.
  - Recurring Slope Lineae now detected in near-equatorial Valles Marineris and in some northern basins, as well as in southern mid-latitudes.
- **MAVEN (prime mission)**
  - Detected UV aurora away from regions of remnant magnetism.
  - Data indicate the presence of small dust particles at 150-300 km altitude.
  - Details of solar wind-atmosphere interaction emerging as coverage expands.